

Loxsomopteris anasilla, a New Fossil Fern Rhizome from the Cretaceous of Maryland

JUDITH E. SKOG*

A fusinized fern rhizome from the Lower Cretaceous beds of the Patuxent Formation (Potomac Group) in College Park, Maryland, is here described as a new genus and species. This rhizome is the first from a locality that was uncovered after the flooding of tropical storm Agnes in 1972.

Locality and stratigraphy.—In June 1972, flooding that followed a tropical storm uncovered Cretaceous clays containing plant remains in College Park, Maryland, near Washington, D.C. The predominantly grey to dark grey color, sandy lithology, and mica content of the outcrop, as well as its geographic position to the west of overlying Arundel and Patapsco strata, indicate its placement in the Patuxent Formation (L. J. Hickey, pers. comm.), the lowest of the three of the Potomac Group. A preliminary examination of a pollen preparation from the fossil-bearing bed is consistent with its placement in Zone I of the Brenner (1963) and Doyle (1969) classifications. The age of this zone is probably Aptian, but may range into the Barremian (*Fig. 1*).

Materials and methods.—Many fossils of gymnosperms and ferns corresponding to forms described by Fontaine (1889) and Berry (1911) occur in the clay lens, mainly as small fragments. Although some fragmentation probably occurred prior to fossilization, numerous planes of slippage (slickensides) in the clay are evidence of internal motion subsequent to burial.

The clay material containing the plants was maintained in a wet condition until further preparation was possible. It was bulk macerated in hydrofluoric acid. Larger plant fragments were sieved out; then the smaller fragments were sorted under a dissecting microscope. Some of the remaining residue was centrifuged and prepared for pollen and spore analysis. Fragments for sectioning were embedded in plastic, either in Epon 812 (50% A and 50% B mixture) or in Spurr Firm Embedding Medium. Sections were cut on a rotary microtome and mounted on microscope slides in Canada balsam. Observations and photographs were made using a Wild M-5 microscope and a Nikon S-Kt microscope with a combination of transmitted and reflected light. Photographs utilized Kodak Plus-X Pan film.

Description.—The well-preserved rhizome is approximately 2 cm long and 5 mm in diameter, with several roots (2.6 mm in diam.), two nodes, and a covering of hairs (some pointed and some blunt) that is more dense at the nodes. The carbonized remains of the rhizome are preserved as fusain (Schopf, pers. comm.) of a type not derived through fire (Schopf, 1975). The cell walls are opaque, brittle,

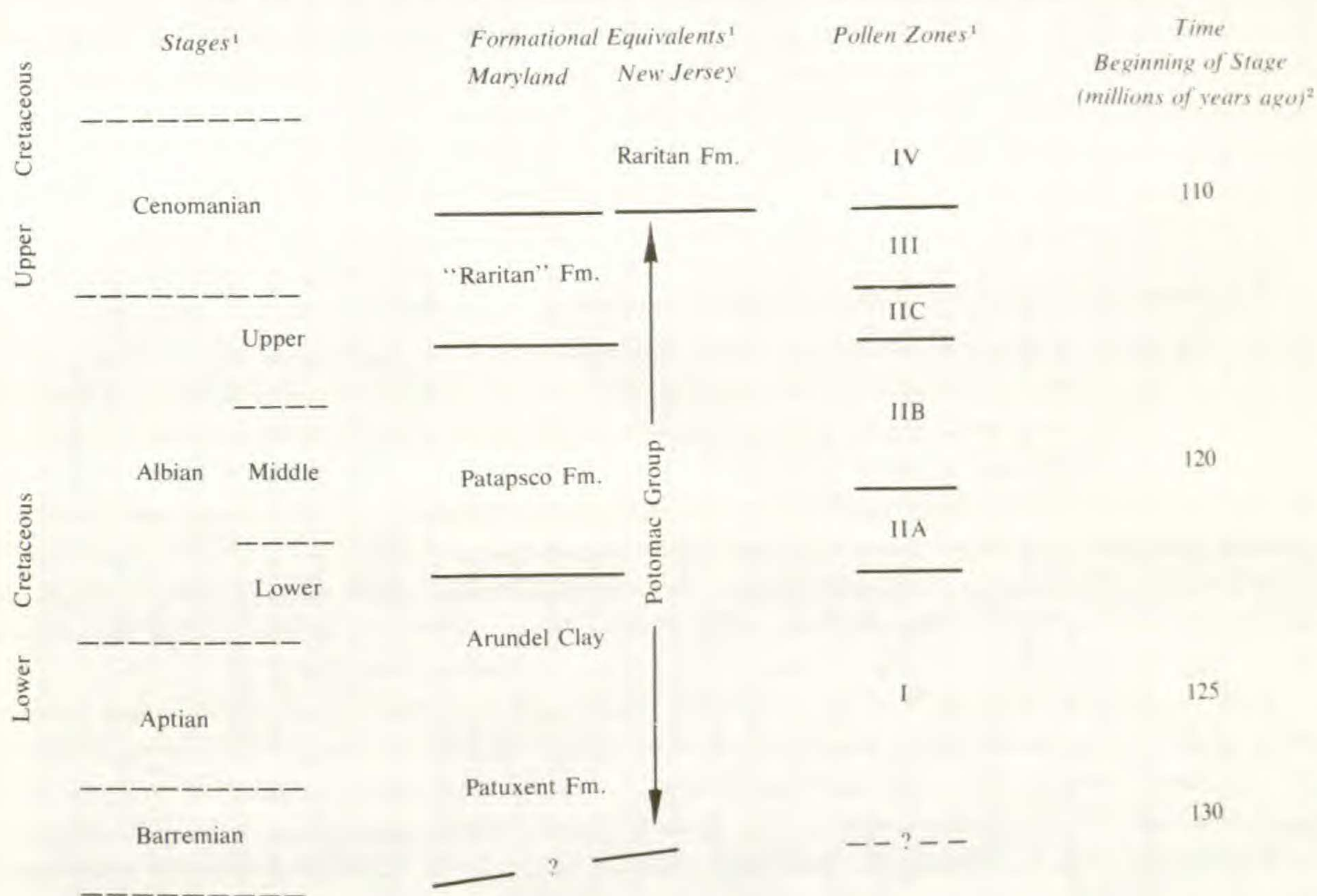
*Research Associate, Division of Paleobotany, Smithsonian Institution, Washington, DC 20560 and Department of Biology, George Mason University, Fairfax, VA 22030.

¹The author is deeply indebted to Dr. Francis M. Hueber, Division of Paleobotany, Smithsonian Institution, for support and encouragement in all phases of the study, to Dr. Leo J. Hickey of the same department for information on the Cretaceous deposits in the area, and to the Division of Paleobotany for providing the laboratory space for the research. She also thanks Charles R. Parker for his assistance with the photographs.

glistening, and show smooth, conchoidal fractures, corresponding to Schopf's (1948) description of fusinized plant tissues. During the dehydration process for embedding in plastic, many of the brittle hairs lost their pointed tips, but the multicellular, bulbous bases remained and can be seen in section (*Fig. 3*). Some sections show the uniseriate tips of the hairs (*Fig. 5*). The cells of the hairs measure 16–33 μm in diameter.

In section the rhizome is solenostelic with a sclerotic pith (cells 16–33 μm in diam.). The xylem is well preserved and is composed of scalariform tracheids (*Fig. 4*), protoxylem tracheids 12–17 μm in diam., and metaxylem tracheids 18–30 μm in diam. Maturation of the xylem is exarch with the protoxylem surrounding

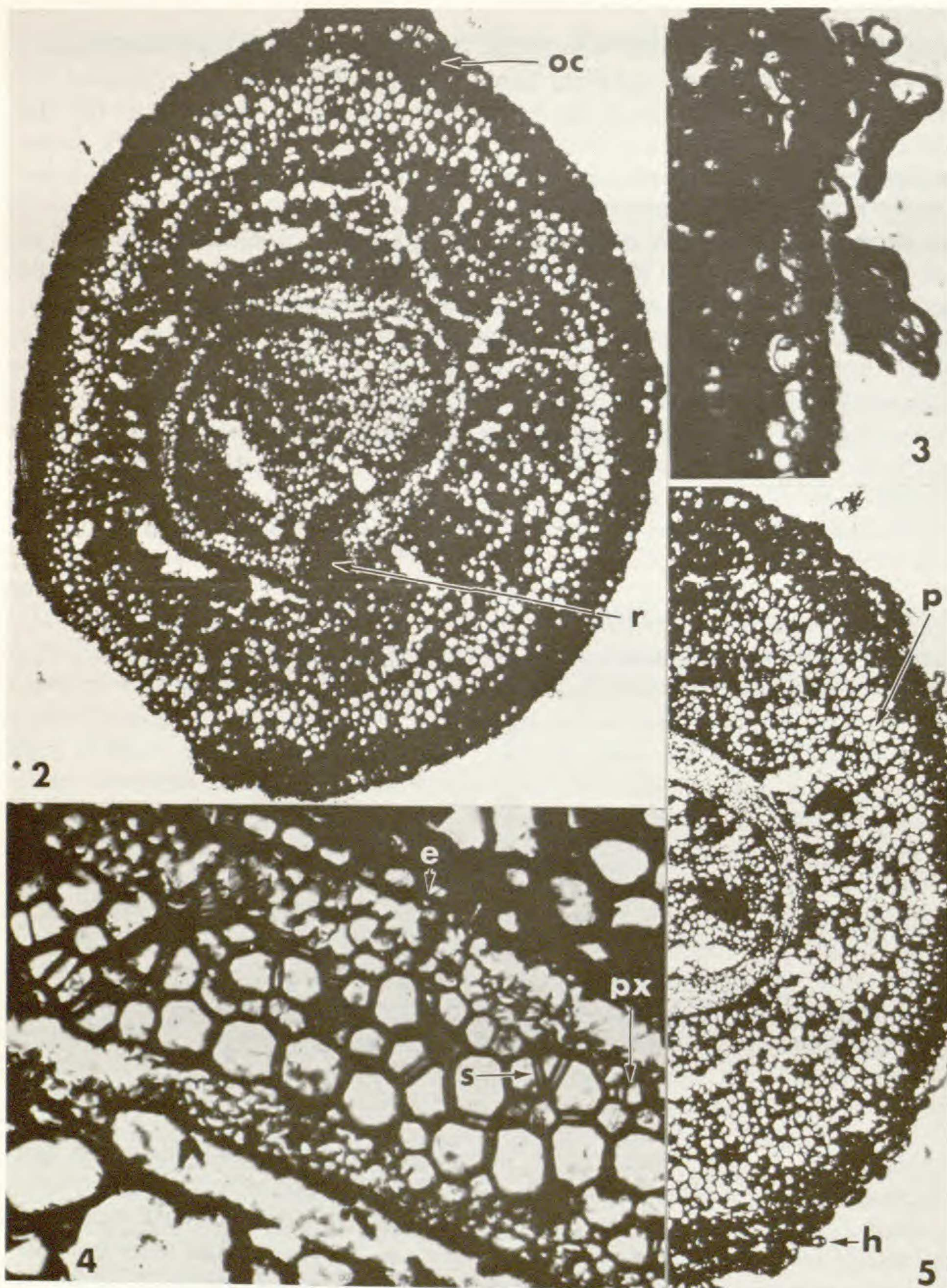
FIG. 1. Stratigraphic relations of the Potomac Group in Maryland.



¹Correlations of units from Doyle et al. (1976).

²Approximate dates from Dickinson and Rich (1972).

this tissue (*Fig. 4*). The phloem (cells 5–8 μm in diam.) surrounds the xylem and contains parenchyma cells 7–12 μm in diam. There is an endodermis of rectangular cells 8–12 μm in diam. around the stele, although this tissue is poorly preserved and difficult to distinguish (*Fig. 4*). The cortex is composed of an inner layer of mixed sclerenchyma (cells 13–23 μm in diam.) and parenchyma (cells 26–46 μm in diam.) and an outer layer of dense sclerenchyma (*Fig. 2*). The epidermis is a layer of isodiametric cells with hairs arising from them. The roots appear to arise from the protoxylem area and become diarch as they pass through the cortex (*Fig. 2*). Petiole traces are poorly preserved, but appear C-shaped and produce a gap in the stele as they are formed. No petiole traces are preserved outside the cortex.



FIGS. 2-5. Anatomical details of *Loxsomopteris anasilla*. FIG. 2. Cross section of rhizome (USNM 208539 c-1), $\times 50$. FIG. 3. Cross section of outer cortex and epidermis with multicellular bases of hairs, $\times 150$. FIG. 4. Cross section of portion of stele, $\times 600$. FIG. 5. Cross section of part of rhizome (USNM 208539 c-10), $\times 50$. The abbreviations are: e = endodermal cells, h = uniseriate portion of hair, p = parenchyma in the cortex, px = protoxylem, r = root production, and s = scalariform thickening of metaxylem tracheids.

Loxsomopteris J. E. Skog, gen. nov.

Fern rhizome covered with bristle-like hairs, these multicellular at the base and tapering to a uniseriate tip, with a sclerotic pith, solenostele, exarch xylem maturation, and a cortex of mixed parenchyma and sclerenchyma (*Fig. 2*).

TYPE: *Loxsomopteris anasilla* J. E. Skog.

Loxsomopteris anasilla J. E. Skog, sp. nov.**Figs. 2-5.**

Rhizome dorsiventral, terete in cross section, solenostelic, covered with bristle-like hairs; hairs multicellular at the base, tapering to a uniseriate tip; outer cortex sclerenchymatous, inner cortex of sclerenchyma and parenchyma; endodermis present; xylem of scalariform tracheids, maturation exarch with protoxylem area around the periphery of the tissue; phloem with sieve elements and parenchyma surrounding the xylem; pith sclerotic; petiole traces C-shaped; roots diarch.

TYPE: United States National Museum 208539, a, b, and c 1-21, series of mounted slides, all deposited in the Paleobotany Collections, U. S. National Museum of Natural History.

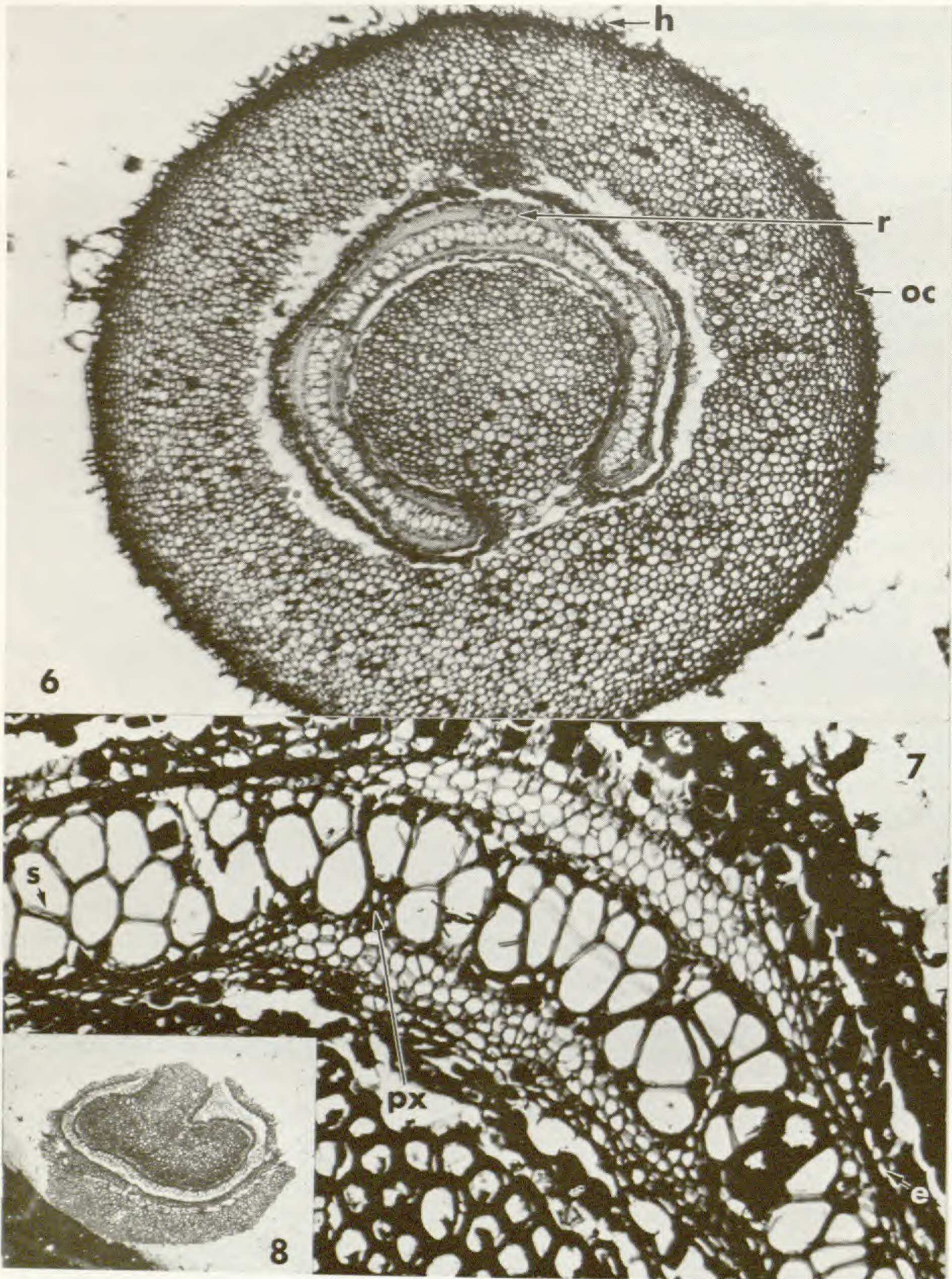
TYPE LOCALITY: Paint Branch, 39°00' N Lat., 76°56' W Long., on the creek bank 500 ft NW of the intersection Greenbelt Road and Route US-1, College Park, Maryland, U. S. A.; USNM locality 14212.

STRATIGRAPHY: Lower Cretaceous Barremian or Aptian, Potomac Group, Patuxent Formation.

DERIVATION OF THE EPITHET: From the Greek *anásillos*, meaning with bristling hairs.

The amphiphloic siphonostele, exarch maturation of the xylem, scalariform tracheids, sclerenchymatous pith, mixed cortex, size of the stem, and relative age relate *L. anasilla* to the form genus *Solenostelopteris* Kershaw (1910). Based upon her description and a reexamination of the type material in the British Museum (Natural History) Paleobotany Collection (*Fig. 8*), *Loxsomopteris* differs from *Solenostelopteris* in cortical arrangement of sclerenchyma and parenchyma, presence of epidermis, age, locality, and size. The outer cortex and epidermis of *S. japonica* are not present, and so there is no indication of hairs on the type species. Kershaw (1910) suggested possible relationships with the Davallieae and, in particular, the extant fern genus *Microlepia*. Her opinion was based on the distribution of sclerenchyma in the cortex, the arrangement of the xylem and phloem, and the marginal thickening of the xylem in forming the leaf gap.

A second species of *Solenostelopteris* was described by Ogura (1930) from the Upper Cretaceous of Japan as *S. loxsomoides*. This species and *L. anasilla* appear to be closely related, particularly in the possession of hairs on the epidermis. The hairs of *S. loxsomoides* are conical, multicellular, and arise from the outer cortex, which is composed of large, thin-walled cells. Ogura's diagram and illustration together do appear to show this sort of structure; however, the question arises as to whether the protrusions are hairs. The epidermis is not clear from the illustration, and if these are truly hairs it is unlikely that the cortex would participate as extensively in their formation as has been illustrated. Thus, although *S. loxsomoides* may very well belong in the new genus *Loxsomopteris*, it



FIGS. 6-8. Anatomical details of *Loxsomopsis* and *Solenostelopteris*. FIG. 6. Cross section of *L. costaricensis* (Mickel 3001, US), $\times 11$. FIG. 7. Cross section of portion of stele of *L. costaricensis*, with the pith in the lower portion of the photograph, $\times 54$. FIG. 8. Cross section of the type of *S. japonica*, specimen v-28872a (Stopes no. 1YA-21a), $\times 8$. Same as Kershaw (1910, fig. 3); photograph courtesy of the British Museum (Natural History). The abbreviations are: e = endodermal cells; h = multicellular base of hair; oc = sclerenchymatous outer cortex, px = protoxylem, r = production of root, and s = scalariform thickening of metaxylem tracheids.

seems advisable to let it remain in the form genus *Solenosteleopteris* until the type specimen has been reexamined. *Loxsomopteris* differs in having hairs with pointed tips arising from the epidermis, a sclerotic outer cortex, and is terete in cross section rather than elliptic. A further distinction between *S. japonica* and *L. anasilla* is that the inner cortex is composed of thick-walled cells in the former. Ogura suggested a close relationship with *Loxsoma* (Loxsomaceae), reflected in the specific epithet, based upon the indument and stelar pattern.

Two other species, *S. nipanica* and *S. sahnii*, were described by Vishnu-Mittre (1958) of Jurassic age from India, but neither of these was described as having hairs on the epidermis.

On the basis of locality, age, sclerotic outer cortex, and the characteristic hairs on the epidermis, the specimen from Maryland is described as a new genus in the family Loxsomaceae. The systematic position of *Loxsomopteris* is difficult to determine because of the lack of attached fronds. Further work on the pinnules found in the same deposit is continuing, and may eventually suggest a more certain relationship. On the basis of the epidermal appendages, relationship with Loxsomaceae is clearly suggested. Within that family, *Loxsomopteris anasilla* can probably be compared most closely with *Loxsomopsis costaricensis*. The hairs of the latter species are multicellular at the base tapering to uniseriate tips, and the points may break off leaving some hairs blunt with only the bulbous bases remaining (Fig. 6). Anatomically, the fossil is strikingly similar to the living fern (Fig. 7) in the solenostele, sclerenchymatous pith, mixed cortex with the outer layer of sclerenchyma, exarch maturation of the xylem with protoxylem areas around the xylem, similar production of diarch roots, and C-shaped petiole trace at its point of origin. However, because no attachment to fronds is yet available, one must not ignore other possible living relatives of *Loxsomopteris*, although the similarities are not as close to any other genus of extant ferns which has a solenostelic vascular system. According to Gwynne-Vaughan (1903, p. 727), the exarch protoxylem seems to limit comparison to *Loxsoma*, *Dicksonia* [*Dennstaedtia*] *apiifolia*, *Davallia platyphylla*, *D. speluncae*, *D. hirta*, or *D. marginalis*. The genus *Davallia* can be eliminated from comparison because of the presence of paleae instead of hairs, and *Dennstaedtia* does not possess the bulbous-based hairs (Bower, 1926). In Loxsomaceae the characteristic islets of parenchyma in the cortex (Gwynne-Vaughan, 1901) are further evidence of the affinities *Loxsomopteris anasilla* has with this family.

The new fossil fern rhizome indicates that the anatomical characteristics typical of the family Loxsomaceae apparently were present in the Lower Cretaceous. However, there is no spore record of this family—or the available spores may not be distinctive enough to determine family relationships. Brenner (1963, p. 31) attributes fern spores of this age to the Matoniaceae, Cyatheaceae, Gleicheniaceae, Schizaeaceae, and Osmundaceae. He interprets the paleoecology of the region as a warm-temperate, broadleaf evergreen rainforest and suggests that these fern families are not inconsistent with this environment. Doyle (1969), on the other hand, suggests the possible presence of Cyatheaceae, Schizaeaceae, and Gleicheniaceae in the Lower Cretaceous, but attributes all

other spores to "groups of less certain affinities," an interpretation which is probably more accurate because trilete spores are found in many families of pteridophytes. Information from the leaf and pinnule types of the Lower Cretaceous must be interpreted with caution, since most of the work on these beds by Fontaine (1889) and Berry (1911) was based upon compression fossils without critical comparative study. Details of leaf anatomy have not yet been investigated, but further work in progress will likely yield a reinterpretation of the groups present.

Previous descriptions of these fossil beds in the Potomac Group (Fontaine, 1889; Berry, 1911) have dealt mainly with compression material. Only the fern *Tempskya* from the Patapsco Formation has been found as a petrification (Berry, 1911, p. 295). This rhizome of *L. anasilla* is therefore interesting, as it is the earliest fossil fern stem from the Lower Cretaceous yet found in Maryland.

That the most closely related species are from the Upper Cretaceous of Japan indicates further evidence of the relationship of eastern Asiatic and eastern North American floras since the Cretaceous. Li (1952) indicates that there are few extant ferns that show this relationship (*Camptosorus*, *Osmunda*, *Onoclea*), possibly because of the production of spores rather than seeds as a dispersal mechanism. Correlation may prove to be closer when ages of Cretaceous continental beds are better defined for Asia and America.

LITERATURE CITED

- BERRY, E. W. 1911. Pteridophyta and Gymnospermae in Clark, W. B. et al. Maryland Geological Survey: Lower Cretaceous. Johns Hopkins Press, Baltimore.
- BOWER, F. O. 1926. The dermal appendages of the ferns. *Ann. Bot.* **40**: 479-490.
- BRENNER, G. J. 1963. The spores and pollen of the Potomac Group of Maryland. *Bull. Maryland Dept. Geol. Mines, Water Res.* **27**: 1-215.
- DICKINSON, W. R. and E. I. RICH. 1972. Petrologic intervals and petrofacies in the Great Valley Sequence, Sacramento Valley, California. *Bull. Geol. Soc. Amer.* **83**: 3007-3024.
- DOYLE, J. A. 1969. Cretaceous angiosperm pollen of the Atlantic coastal plain and its evolutionary significance. *J. Arnold Arb.* **50**: 1-35.
- , M. VAN CAMPO and B. LUGARDON. 1976. Observations on exine structure of Eucommiidites and Lower Cretaceous angiosperm pollen. *Pollen & Spores* **18**: (in press).
- FONTAINE, W. M. 1889. The Potomac or Younger Mesozoic flora. U.S. Geol. Surv. Monogr. **15**: i-xiv, 1-377, t. i-clxxx. Government Printing Office, Washington, D. C.
- GWYNNE-VAUGHAN, D. T. 1901. Observations on the anatomy of solenostelic ferns. I. *Loxosoma*. *Ann. Bot.* **14**: 71-98.
- . 1903. Observations on the anatomy of solenostelic ferns. Part II. *Ann. Bot.* **17**: 689-742.
- KERSHAW, E. M. 1910. A fossil solenostelic fern. *Ann. Bot.* **24**: 683-691.
- LI, H.-L. 1952. Floristic relationships between eastern Asia and eastern North America. *Trans. Amer. Phil. Soc. n.s.*, **42**: 371-429.
- OGURA, Y. 1930. On the structure and affinities of some Cretaceous plants from Hokkaido. *J. Fac. Sci., Imp. Univ. Tokyo, III*, **2**: 381-413, pl. XVIII-XXI.
- SCHOPF, J. M. 1948. Variable coalification: the processes involved in coal formation. *Econ. Geol.* **43**: 207-225.
- . 1975. Modes of fossil preservation. *Rev. Paleobot. Palynol.* **20**: 27-53.
- VISHNU-MITRE. 1958. Studies on the fossil flora of Nipania, Rajmahal Series, India-Pteridophyta, and general observations on Nipania fossil flora. *The Palaeobotanist* **7**: 47-66.